

**We claim:**

1. A single mode optical waveguide fiber having a radial and azimuthal asymmetric core comprising:

5 a core region in contact with a surrounding clad layer, at least a portion of the core region having a refractive index which is greater than the refractive index of at least a portion of the clad layer;

10 said core region having a centerline extending along the waveguide fiber length and being divided into at least a first and a second set of diagonally opposed sectors, wherein the first set of diagonally opposed sectors have a radial change in refractive index defined by a function  $f(r)$ , and the second set of diagonally opposed sectors have a radial change in refractive index defined by a function  $g(r)$ , wherein  $f(r)$  is an  $\alpha$ -profile or a rounded step profile and  $g(r)$  is a step profile.

15 2. The single mode waveguide fiber of claim 1 wherein the respective diagonally opposed sectors are mirror images of each other.

3. The single mode optical waveguide fiber of claim 1 or 2 wherein the respective sectors each have equal volume.

20 4. The single mode optical waveguide fiber of claim 1 wherein the function  $g(r)$  is defined over a radius range  $\Delta r_g$  and the function  $f(r)$  is defined over a radius range  $\Delta r_f$  and  $\Delta r_g \neq \Delta r_f$ .

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9. The single mode waveguide of claim 2, in which, the core has 4 sectors of equal volume, the bounding planes of each sector having an included angle of  $90^\circ$ , the refractive index profile of each sector having a central portion of radius  $r_c$  and relative index  $\Delta_c$ , extending between the planes bounding the sector,

a first annular region in contact with the central portion, having outer radius  $r_1$ , relative index  $\Delta_1$ , and extending between the planes bounding the sector,

a second annular region in contact with the first annular region, having outer radius  $r_2$ , relative index  $\Delta_2$ , and extending between the planes bounding the sector,

a third annular region in contact with the second annular region, having outer radius  $r_3$ , relative index  $\Delta_3$ , and extending between the planes bounding the sector,

a first volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the first plane

bounding the sector and bounded on a second part of its surface by a part of the first, second, and third annular regions,

5 a second volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the second plane bounding the sector and bounded on a second part of its surface by a part of the first, second, and third annular regions, wherein,

each of the remaining three sectors contain embedded volumes having surfaces bounded in a way corresponding to the volumes embedded in the first sector, wherein, the relative indexes and the radii follow the inequalities,  
10  $0 \leq r_c < r_1 < r_2 < r_3 \leq r_o$  and  $\Delta_c \geq \Delta_2 > \Delta_1 \geq \Delta_3$ .

10. The single mode waveguide of claim 2, in which the core has three sectors, and each sector comprises a volume of a first glass of constant refractive index embedded in a volume of a second glass of constant refractive index, in which the refractive index of the first glass is greater than the refractive index of the  
15 second glass.

11. The single mode waveguide of claim 10 in which each of the first glass volumes is an elongated body having its long axis aligned parallel to the centerline, wherein the perpendicular cross section of the elongated body is selected from the group consisting of a circle, an ellipse, and a parallelogram.

20 12. The single mode waveguide of claim 2, in which the core has three sectors, and each sector contains an elongated glass volume having a central portion, a first annular portion surrounding and in contact with the central portion, and at least one additional annular portion in contact with the annular portion which the at least one additional annular portion surrounds, wherein the long axis of  
25 each of the elongated structures is parallel to the centerline.

13. The single mode waveguide of claim 12 in which the central portion is a cylinder having radius  $r_c$  and relative index  $\Delta_c$ , and the annular regions are tubes having respective outer radii  $r_i$  and relative index  $\Delta_i$ , where  $i = 1 \dots n$ , and  $n$  is the number of annular portions, in which  $\Delta_i$  for  $i =$  an even number is  
30 greater than  $\Delta_i$  for  $i$  equal to an odd number.

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15. A method of making a radially and azimuthally asymmetric single mode or multimode optical waveguide fiber comprising the steps:

10 a) fabricating a single mode or multimode optical waveguide fiber preform having a long axis, a core, and a clad, wherein any cross section of the preform, perpendicular to the long axis, is circular;

15 b) grinding, sawing, or otherwise removing peripheral portions of the preform to alter the preform surface such that any cross section of the preform taken perpendicular to the long axis has a shape which is essentially the same as the shape of any other cross section of the preform perpendicular to the long axis;

c) heating and drawing the preform along its long axis into a waveguide fiber having a core, a long axis and a circular cross section perpendicular to the long axis at any point along the long axis, to provide a waveguide fiber core having the shape of the altered preform.

20 16. The method of claim 15 in which step b) includes forming one or more indentations in the preform surface.

25 17. The method of claim 16 in which the fabricating step a) includes the step of fabricating a segmented core preform comprising, a central core region and at least one annular portion surrounding and in contact with the central core region, wherein the relative refractive index of the central region is different from the relative refractive index of the annular portion and the one or more indentations penetrate at least into the annular portion.

18. A method of making a radially and azimuthally asymmetric single mode or multimode waveguide comprising the steps:

30 a) fabricating an optical waveguide fiber preform having a long axis, a core, and a clad, wherein any cross section of the preform, perpendicular to the long axis, is circular;